
DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the layer structure design approach of of the simulation system and the exposed substrate using the simulation approach of the profile of a resist pattern and this approach which start the optical lithography technique used for manufacture of a semiconductor integrated circuit, a liquid crystal panel, etc., especially are formed on an exposed substrate, and the design approach of a mask pattern.
[0002]
[Description of the Prior Art] In case the resist pattern configuration formed by the optical lithography technique is predicted by simulation, the count approach shown below has been used.
[0003] The 1st approach is the approach of predicting the pattern dimension and profile formed in the optical intensity distribution irradiated by the wafer front face with the application of slice level (conventional method 1). Said optical intensity distribution are for example, KODAKKU microelectronics seminar interfaces. The approach of calculating using the fast Fourier transform (FFT) indicated by the paper it is [modeling AERIARU IMEJIZU Inn two - and - three DIMENSHONZU (Modeling Aerial Images in Two and Three Dimensions) in '85 (Kodak Microelectronics Seminar Interface '85)] entitled etc. is mentioned. Since count space is also two-dimensional space parallel to an exposed substrate front face, there can also be little data volume, and it can end [this approach has short computation time,], and can respond to the large-scale pattern covering a large area.
[0004] The 2nd approach is the approach of predicting the pattern configuration formed by carrying out optical intensity-distribution count, sensitization agent concentration distribution count, BEKU diffusion count, and development count (conventional method 2). As a simulator using this approach From UCB (University of California Berkley), they are 26 IEEE transactions-on EREKU roton debye cis- ED (1979) (). [IEEE Transactions] onElectron Devices, vol. ED-26 No. 4, April, A in 1979, General simulator FO VIERU S eye lithography -, and - etching pro SESHISU PERT one application two projection lithography () [A] General Simulator for VLSI Lithography and Etching Processes: Part I - Application toProjection SAMPLE and SAMPLE-3D indicated by the paper it is [Lithography] entitled, And Finley Technologies () [FINLE] Technologies PROLITH indicated by the work entitled from Inc. an inside pro squirrel (Finley Technologies) (Inside Prolith (FINLETechnologies Inc.)) And PROLITH-3D is announced. A conventional method 2 can search for the three-dimension configuration of the resist pattern formed in consideration of the effect of various parameters of optical lithography.
[0005] The 3rd approach is an approach based on an intensive parameter model. The detail is lithography FO buoy El S eye chapter 2 and buoy El S eye electronics micro structure Science Academic Press New York 1987 (). [Chapter] 2 Lithography for VLSI VLSIElectronics-Microstructure Science R.KWatts and N.G.Einspruch, eds. Academic Press () New York: It is indicated by the paper it is [the RUMPUDO parameter model FO optical lithography (Lumped Parameter Modelfor Optical Lithography) in 1987] entitled (conventional method 3). This model is based on the development theory-expression about the simple model about a development rate, and a development process. The

effectiveness of development can be taken into consideration by short computation time.
[0006] The 4th approach is an approach of simplifying and expressing a resist process. proceeding OBU and S Py eye I optical micro lithography [ ] -- 2726 volumes (1996) (Proceeding of SPIE, Optical Microlithography, and Vol.2726 --) Are indicated by the paper it is [APUROKISHI mate MODERUZU FO resist processing EFEKUTSU (Approximate Models for Resist Processing Effects) in 1996] entitled. (Conventional method 4) . The effectiveness of development is simplified and expressed and it is computable at short computation time.
[0007] One of the attempts which performs optical proximity effect correction (OPC) using a conventional method 1 is called the simulation base OPC. For example proceeding OBU and S Py eye I optical micro lithography [ ] -- 2726 volumes (1996) (it Microlithograph(ies) Proceeding of SPIE and Optical [ ] --) MASEMA tee cull - and - C A dee framework FO PUROSHI in vol.2726 and 1996 -- a you tee collection () [Mathematical and CAD Framework] for Proximity It is indicated by the paper it is [Correction] entitled. It is the approach of amending the configuration of a mask pattern so that a desired pattern may be formed based on the optical intensity distribution calculated by the conventional method 1.
[0008] Moreover, there is a rule base OPC as another attempt in which OPC is performed using a conventional method 1. proceeding OBU S and Py eye I optical laser micro lithography [ ] -- 2197 volumes (1994) (it Microlithograph(ies) Proceeding ofSPIE and Optical/Laser [ ] --) automation TIDO- in vol.2197 and 1994 -- optical - pro squeak tee collection A RURUZU based approach () [Automated optical proximity correction] - a rules-based It is the approach of amending a mask pattern configuration based on the approach indicated by the paper it is [approach] entitled.
[0009] Moreover, the approach of predicting a direct pattern configuration from the sensitization agent concentration distribution in a resist is indicated by JP,10-256120,A.
[0010]
[Problem(s) to be Solved by the Invention] The trouble of the above-mentioned conventional method which predicts a resist pattern configuration is as follows.
[0011] In a conventional method 1, change of the pattern configuration depending on resist thickness, substrate layer structure, an antireflection film, etc. cannot be predicted.
[0012] Although it asks to the cross-section configuration of a resist pattern in a conventional method 2, it is difficult for data volume to also become large and to calculate with practical computation time and data volume to a large-scale pattern, since computation time is long and it is three-dimension count.
[0013] In a conventional method 3 and a conventional method 4, although the effectiveness of development can be taken into consideration, it cannot predict change of the resist pattern dimension and profile under the effect of the standing wave effectiveness depending on resist thickness, substrate layer structure, the antireflection film, etc.
[0014] On the other hand, in the simulation base OPC and the rule base OPC which perform optical proximity effect correction based on the above-mentioned conventional method 1, in consideration of the effect of the standing wave effectiveness depending on resist thickness, substrate layer structure, antireflection film, etc. of an exposed substrate, a mask pattern configuration cannot be amended so that a desired resist pattern profile may be obtained.
[0015] Moreover, by the approach indicated by JP,10-256120,A, there is a problem in respect of how defining a threshold lessening not becoming common and data volume.
[0016] The technical problems of this invention are short computation time and small data volume, and are offering the simulation approach which can predict change of the resist pattern dimension and profile under the effect of the standing wave effectiveness depending on setups, such as resist thickness, substrate layer structure, and antireflection film.
[0017] Moreover, other technical problems of this invention are offering the approach of designing layer structure and thickness, such as resist thickness of an exposed substrate, a substrate layer, and an antireflection film, so that a good pattern's can be formed in consideration of the effect of the standing wave effectiveness depending on resist thickness, substrate layer structure, an antireflection film, etc. of an exposed substrate using this simulation approach.

[0018] The technical problem of further others of this invention is offering the approach of designing a mask pattern so that a good pattern's can be formed, in consideration of the effect of the standing wave effectiveness depending on resist thickness, substrate layer structure, an antireflection film, etc. of an exposed substrate.

[0019]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, in this invention, count of the average sensitization agent concentration distribution on a resist thin film flat surface is introduced in consideration of the effect of the standing wave effectiveness depending on the thickness, refractive index and sensitization parameter of the resist in an exposed substrate, the layer structure, thickness and complex index of refraction of a substrate layer, thickness, complex index of refraction of the antireflection film, etc.

[0020] Namely, the process as which the simulation approach of this invention inputs a mask pattern configuration, the wavelength of exposure light, the numerical aperture of a lens, lighting conditions, and the conditions of defocusing, The process which calculates distribution of the exposure light irradiated by the front face of the exposed substrate containing a resist layer, The process which inputs the conditions of light exposure, the thickness, refractive index and sensitization parameter of a resist, the structure, thickness and complex index of refraction of a substrate layer, the thickness and complex index of refraction of an antireflection film, and the complex index of refraction of a substrate, The process which calculates the sensitization agent concentration distribution in said resist layer, and calculates average sensitization agent concentration distribution by averaging said sensitization agent concentration distribution in the depth direction of a resist layer, The process which finds a development rate as a function of sensitization agent concentration based on an input parameter, The process which calculates the sensitization agent concentration threshold corresponding to a predetermined development rate, and the process which carries out the numerical calculation of the pattern profile after the development of said resist to said average sensitization agent concentration distribution with the application of the above-mentioned sensitization agent concentration threshold, It is characterized by consisting of a process which displays the pattern profile obtained by count.

[0021] among these, about count of sensitization agent concentration 22 IEEE transactions-on EREKU roton debye cis- ED (1975) () [IEEE Transactions on Electron Devices,] [vol.] ED-22 No. 7 With the sensitization model of Dill indicated by the paper it is [July and the character rye ZESHON OBU positive photoresist (Characterization of Positive Photoresist) in 1975] entitled As the sensitization agent concentration distribution M in a resist layer (x y, z) is calculated first and it is shown in drawing 2 below From a point (x y), M (x y, z) is averaged from a resist top face (z= 0) to the interface (z=zd) of a resist and a substrate layer, and it asks for the average sensitization agent concentration Mm (x y) by several 1.

[0022]

[Equation 1]

$$M_m(x,y)=\frac{1}{z_d}\int_0^{z_d} M(x,y,z)dz \qquad \cdots\cdots (1)$$

[0023] However, zd is resist thickness. This actuation is performed to (x, y) of the count field whole region.

[0024] Next, if the sensitization agent concentration threshold Mth is applied to Mm (x y) and it is set to it Mm(x y) <Mth in POJIREJISUTO, a resist will be removed by development, and if it becomes Mm(x y) >Mth, it will calculate a resist pattern dimension and a profile, assuming after development that a resist remains. In NEGAREJISUTO, this relation becomes reverse.

[0025] A sensitization agent concentration threshold here The development model of Above Dill, or journal OBU electrochemical society 134 volumes (1987) () [Journal] of Electrochemical Society vol. 134, No. 1 January With the development model of Mack indicated by the paper it is [the DIBEROPPUMENTO OBU positive photoresist (Development of Positive Photoresists) in 1987]

entitled etc. It was presupposed that it is the value of the sensitization agent concentration in the point of inflection of a development velocity curve in the sensitization agent concentration dependency of the development rate obtained.
[0026] However, when a sensitization agent concentration value does not have said point of inflection between 0 and 1, the threshold currently indicated by JP,10-256120,A, i.e., the value whose dimension calculated to the given light exposure corresponds with an experimental value mostly, is used as a threshold. This threshold may be adopted when a sensitization agent concentration value has said point of inflection between 0 and 1.
[0027] By this count approach, as shown in drawing 6 , compared with the conventional method 2 which calculates all the main processes of optical lithography, computation time is about 1 / 9 - 1/10. Moreover, after asking for M (x y, z) by this count approach from the value existing (x y), in order for one above to average in the depth direction (the direction of z) of a resist layer immediately and to calculate Mm (x y), the data which must be stored by computation are not three-dimensional-array M (x y, z) but the two-dimensional array Mm (x y). Therefore, the data memory in a computer is the almost same order as optical intensity-distribution count of a conventional method 1.
[0028] For example, if the depth directions (the direction of z) of 0.01 micrometers and a resist layer of the mesh division width of face of x and the direction of y level in a resist layer about a 2.56-micrometer one-side square field are 120 division, since optical intensity-distribution count of a conventional method 1 is two-dimensional array, the number of joints needed is 256x256=65536. Moreover, by this count approach, if it is 103, since the data of a sensitization agent concentration table are given in division of light exposure by x (the number of partitions of light exposure = 103) (the number of partitions of the direction of z = 120) in addition to the joint 65536 of two-dimensional array, it is 12360. Therefore, the number of joints required of this count approach is 65536+12360=77896.
[0029] On the other hand, since a three dimensional array is needed in a conventional method 2, the number of joints needed is 256x256x120=7864320.
[0030] If the count approach of this invention is used as mentioned above, it will become possible to predict the pattern dimension and profile which are formed of optical lithography in consideration of the effect of the resist thickness of an exposed substrate, substrate layer structure, and the layer structure of an antireflection film etc. in a large area almost like optical intensity-distribution count of a conventional method 1.
[0031]
[Embodiment of the Invention] As an example of this invention, here mainly shows the pattern formation by KrF excimer laser lithography. Moreover, this invention is not limited by the following operation gestalten although it is natural.
[0032] (Example 1) The flow chart of the simulation approach of the resist pattern profile of this invention is shown in drawing 1 . In the simulation approach shown in drawing 1 , as shown in drawing 2 , system of coordinates made the direction parallel to an exposed substrate front face x and a y-coordinate, and made the z-coordinate the direction perpendicular to an exposed substrate front face.
[0033] First, the optical intensity distribution I (x y) irradiated by the exposed substrate front face are calculated (processing 1). Next, to the value existing (x y), the sensitization agent concentration distribution M in a resist layer (x y, z) is calculated, and the average sensitization agent concentration distribution Mm (x y) is calculated with said-one number. This actuation is performed to (x, y) of the count field whole region (processing 2). The resist pattern dimension and profile formed are calculated by applying the sensitization agent concentration threshold Mth obtained by the development velocity curve etc. to distribution of Mm (x y) obtained by processing 2 (processing 3). The resist pattern dimension and profile obtained by I (x y) obtained by processing 1, Mm (x y) obtained by processing 2, and processing 3 are displayed (processing 4).
[0034] The outline of a simulation system based on the simulation approach of this invention is shown in drawing 3 . This system consists of the data input section 12, the data-processing section 13, and the graphical representation section 14. In optical intensity-distribution simulation, in the data input section 12, the wavelength of exposure light, lighting conditions, the numerical aperture of a lens, a mask

pattern, and the data of defocusing are inputted, the optical intensity distribution irradiated by the exposed substrate front face through a contraction projection aligner in the data-processing section 13 by the optical intensity-distribution simulator are calculated, and a screen display of the optical intensity distribution is carried out in the graphical representation section 14. About average sensitization agent concentration distribution simulation, first, it is the data input section 12 and thickness, such as thickness of exposure conditions and the thickness of a resist, a refractive index, an exposure parameter, and a substrate layer, complex index of refraction, and an antireflection film, complex index of refraction, and the complex index of refraction of a substrate are inputted.

[0035] Next, the optical intensity distribution in the exposed substrate front face obtained by the optical intensity-distribution simulator are used as surface conditions in the data-processing section 13, and the resist pattern dimension and profile in which it is formed [over which are formed and it is average-sensitization-agent-concentration-distributed] in a resist by the average sensitization agent concentration distribution simulator are calculated. Finally, the resist pattern dimension and profile formed [are formed and it is average-sensitization-agent-concentration-distributed] are displayed in the graphical representation section 14.

[0036] Next, the result of having examined the defocusing dependency of the dimension fluctuation resulting from the standing wave effectiveness is shown using this simulation approach.

[0037] Here, the resist thickness dependency of the pattern dimension in the case of imprinting 0.30-micrometer Rhine / tooth-space pattern (binary mask) to a chemistry magnification positive resist was calculated by making KrF excimer laser into the light source. It was presupposed that the conditions of optical count are numerical-aperture NA=0.50 of the wavelength of lambda= 0.248 micrometers of exposure light, and a lens, and lighting is the usual lighting of sigma=0.60. In light exposure Dose=170mJcm-2 and a resist, APEX-E (product made from Shipley) and the sensitization parameter of Dill presupposed [the conditions of average sensitization agent concentration distribution count] that the complex index of refraction of NResist=1.74 and Substrate Si is the refractive index of A=-0.01micrometer-1, B=0.362micrometer-1, C= 0.0033cm2/mJ, and a resist nSi=1.56-i and 3.565. Moreover, the sensitization agent concentration threshold used Mth=0.80 obtained with a Mack model.

[0038] The resist thickness dependency (swing jazz curve) of the resist pattern dimension CD calculated under said conditions to drawing 7 is shown. The amplitude of a swing jazz curve was set to 0.134 micrometers, when Defocusing df was 0.0 micrometers and 0.096 micrometers and Defocusing df were 0.5 micrometers. Drawing 7 showed that it was not based on change of defocusing but the resist thickness from which a dimension becomes fixed existed under the conditions of this example.

[0039] The defocusing dependency of amplitude deltaCD of the swing jazz curve under the above-mentioned conditions is shown in drawing 8 . The value of deltaCD also increased with the increment in defocusing, and the curved inclination became sudden. deltaCD in case defocusing is 0.6 micrometers is 0.159 micrometers, and became about 1.66 times at the time of a best focus.

[0040] The result of having asked drawing 9 for the resist thickness dependency of the maximal value Mm (xmax) of the average sensitization agent concentration Mm in a certain resist thickness (x) and the minimal value Mm (xmin) under the above-mentioned conditions is shown. Here, the pitch direction of Rhine / tooth-space pattern presupposed that they are x directions, and xmax and xmin presupposed that it is the x-coordinate from which Mm (x) serves as the maximum and the minimum.

[0041] When drawing 9 was compared with drawing 7 , and it was the resist thickness from which Mm (xmax) and Mm (xmin) serve as the maximum, and CD serves as the minimum when it is the resist thickness from which it is not based on a defocusing value, but the resist pattern dimension CD formed serves as the maximum, Mm (xmax) and Mm (xmin) became the minimum. Under the conditions of this example, change of as opposed to resist thickness in the direction of Mm (xmin) is large, and change of as opposed to defocusing in the direction of Mm (xmax) is large.

[0042] Here, with the application of the maximal value Mm (xmax) and the minimal value Mm (xmin) of average sensitization agent concentration, the formula of average sensitization agent concentration contrast is defined as the formula of optical contrast like the following several 2.

[0043]

[Equation 2]

$$Cont_{M_m} = \frac{M_m(x_{max}) - M_m(x_{min})}{M_m(x_{max}) + M_m(x_{min})} \quad \cdots\cdots (2)$$

[0044] The resist thickness dependency of the average sensitization agent concentration contrast CountMm searched for by several 2 is shown in drawing 10 . When drawing 1010 was compared with drawing 7 , and it was the resist thickness from which a resist pattern dimension serves as the minimum and the maximum, CountMm became the maximum and the minimum. Moreover, as for CountMm, the direction whose defocusing is 0.5 micrometers fell.
[0045] As mentioned above, the dimension range of fluctuation increased under the effect of defocusing, and it was shown by the average sensitization agent concentration model that average sensitization agent concentration contrast falls. Moreover, under the conditions of this example, since the resist thickness zd (for example, zd=0.830micrometer) from which it is not based on defocusing but a dimension becomes fixed existed, it was able to be shown that resist thickness can be set up so that effect of the dimension fluctuation by defocusing may be made into min.
[0046] (Example 2) An example 2 shows the example which sets up a sensitization agent concentration threshold based on the sensitization agent concentration dependency of a development rate. Here, the development parameter was aimed at i line resist known well. With the development model of above Dill, the dependency over the sensitization agent concentration M of a development rate is given by several 3.
[0047]
[Equation 3]

$$R(M) = E_1 + E_2 M + E_3 M^2 \quad \cdots\cdots (3)$$

[0048] The result of having asked drawing 4 for the development rate of the resist whose development rate parameters are E1=5.96, E2=-1.19, and E3=-2.27 is shown. From drawing 4 , since the 0.3 neighborhoods had become curved point of inflection, sensitization agent concentration set the threshold Mth of the sensitization agent concentration of this resist as 0.3.
[0049] Next, the example which carried out simulation about the pattern formation using this resist is shown. The mask pattern presupposed that it is 0.36-micrometer isolated hole pattern. The conditions of optical intensity-distribution count were set to numerical-aperture NA=O.55 of the wavelength of lambda= 0.365 micrometers of exposure light, and a lens, and lighting was set to the usual lighting of sigma=0.3, and defocusing df=0.0micrometer. Moreover, the conditions of average sensitization agent concentration distribution count presupposed that light exposure Dose=150 mJ/cm2 and the sensitization parameter of Dill are A=0.74micrometer-1, B=0.20micrometer-1, C= 0.012cm2/mJ, refractive-index nResist=1.72 of a resist, and complex-index-of-refraction nSi=6.50-i-2.61 of Substrate Si.
[0050] The average sensitization agent concentration distribution for which drawing 5 was asked under said conditions is shown. drawing 5 -- setting -- a contour line -- the order from an outside -- Mm(x y) =0.9, 0.8, 0.7, 0.6, 0.5, 0.4, and 0. -- it is 3 and 0.2. Here, the contour line of 0.3 corresponding to a threshold is displayed thickly, and expresses the pattern profile formed. Here, since a resist is POJIREJISUTO, the value of Mm (x. y) supports the field to which a resist is removed for 0.3 or less place. Drawing 5 (a) is the case where it is resist thickness zd=1.00micrometer from which a hole dimension serves as the maximum, and this drawing (b) is the case where it is resist thickness zd=1.06micrometer from which a hole dimension serves as the minimum. The hole profile formed in consideration of the effect of resist thickness has been predicted by applying the threshold 0.3 which used and set drawing 4 as the average sensitization agent concentration distribution shown in drawing 5 .

[0051] Next, computation time is described. A mask pattern presupposes that they are 0.40-micrometer Rhine / tooth-space pattern. Count conditions presupposed that it is the same as that of the example

shown in drawing 5 except the mask pattern. Moreover, developing time presupposed that it is 90s. The result of having measured the count field length dependency of CPU (Central Processing Unit) time amount with the mainframe M-880 (Hitachi make) is shown in drawing 6 under these conditions. Although the CPU time changed for a while with count field length, and the cross-section configuration of a pattern was not searched for when this count approach was used, it was calculable by the time amount of about 1 / 9 - 1/10 of the conventional method 2 which calculates all the main processes of optical lithography. The pattern profile formed by count of such a short time in consideration of the effect of the standing wave effectiveness depending on the resist thickness, the substrate layer structure, the antireflection film, etc. of an exposed substrate has been predicted.
[0052] (Example 3) In the example 3, the simulation approach shown in the example 1 considers the effect of the antireflection film in an exposed substrate.
[0053] The exposed substrate dealt with by this example to drawing 11 is shown. here -- the complex index of refraction of the TARC layer 16 -- the complex index of refraction of 1.79-i-0.47 and the BARC layer 18 -- 1.79-i-0.47 and SiO two-layer -- the complex index of refraction of 22 presupposed that it is 1.51-i-0.0. Moreover, the mask pattern presupposed that it is 0.28-micrometer isolated hole pattern (opening pattern on 6.0% halftone mask of permeability).
[0054] The count conditions of the optical intensity distribution irradiated by the front face of an exposed substrate presupposed that it is numerical-aperture NA=0.60 of the exposure wavelength of lambda= 0.248 micrometers, and a lens, coherence factor sigma=0.40 (usually lighting), and defocusing df=0.0. Moreover, the conditions of average sensitization agent concentration distribution count were made into light exposure Dose=200 mJ/cm2, and all input parameters required for others presupposed that it is the same as an example 1.
[0055] About the layer structure 1 and layer structure 2 which are shown in drawing 11 , in order to evaluate the effectiveness of the upper antireflection film TARC layer 16 and the lower layer antireflection film BARC layer 18 "With no TARC-less -BARC (case 1)" and "with those with TARC, and no BARC (case 2)", The resist thickness dependency (swing jazz curve) of the hole dimension formed was calculated about four kinds of "those with TARC-less -BARC (case 3)", and "**** those with TARC, and with BARC (case 4)" of cases. The result is shown in drawing 12 . And the effect affect the diameter of a hole in which a difference of layer structure and a difference of the cross protection in the film by the existence of an antireflection film are formed was considered.
[0056] When there is no antireflection film (case 1), the dimension fluctuation which originates in the standing wave effectiveness by every layer structure is large. Moreover, if layer structures differ, the resist thickness from which a dimension serves as the maximum and the minimum differs. In the case of layer structure 1, in the case of 0.062 micrometers and layer structure 2, the dimension range of fluctuation (amplitude of a swing jazz curve) has been predicted to be 0.064 micrometers.
[0057] It shifted to the one where a dimension is larger in the case 2. The dimension fluctuation to resist thickness is quite smaller than a case 1. In any [of layer structure 1 and layer structure 2] case, the amplitude of a swing jazz curve was 0.006 micrometers.
[0058] It shifted to the one where a dimension is smaller in the case 3. Although the dimension range of fluctuation to change of resist thickness is quite smaller than a case 1, it is somewhat larger than a case 2. In the case of layer structure 1, in the case of 0.015 micrometers and layer structure 2, the amplitude of a swing jazz curve was 0.011 micrometers.
[0059] It shifted to the one where a dimension is smaller in the case 4. The width of face of dimension fluctuation is the smallest of four kinds of the acid-resisting conditions. In any [of layer structure 1 and layer structure 2] case, the amplitude of a swing jazz curve is 0.002 micrometers.
[0060] As mentioned above, the simulation approach shown in the example 1 has estimated the effectiveness of an antireflection film quantitatively as an amount of dimension fluctuation in consideration of the effect of the standing wave effectiveness.
[0061] (Example 4) Using the simulation approach shown in the example 1, an example 4 considers the layout pattern formation using NEGAREJISUTO, and shows how to set up the resist thickness of an exposed substrate so that desired pattern dimension and profile may be obtained.

[0062] The count conditions of the optical intensity distribution irradiated by the front face of an exposed substrate were set to numerical-aperture NA=0.45 of the exposure wavelength of lambda= 0.248 micrometers, and a lens, and lighting was set to sigma=0.3 and defocusing df=0.0micrometer. Moreover, as for light exposure Dose=180 mJ/cm2 and a resist, chemistry magnification negative-resist XP-8843 and the sensitization parameter of Dill presupposed [the conditions of average sensitization agent concentration distribution count] that the complex index of refraction of nResist=1.76 and Substrate Si is the refractive index of A=-0.92micrometer-1, B=1.55micrometer-1, C= 0.0020cm2/mJ, and a resist nSi=1.56-i and 3.565. Moreover, the sensitization agent concentration threshold used Mth=0.90.
[0063] The mask pattern used for drawing 13 here is shown. In drawing 13 , as shown all over drawing, the polygon to which hatching of the void polygon was carried out with the opening mask with a phase of 0 degree and the slash is an opening mask with a phase of 180 degrees, and the other place is the protection-from-light section. The layer structure of the wafer which imprints this pattern to drawing 14 is shown. Layer structure A and layer structure B are adjacently arranged, as shown in drawing 15 .
[0064] The result which carried out simulation with the average sensitization agent concentration model is shown about the layout pattern formation which used negative resist for drawing 16 under the above conditions. the contour line of average sensitization agent concentration -- the order from an outside -- 0.95, 0.90, 0.85, 0.80, 0.75, 0.70, and 0. -- it is 65 and 0.60. The contour line of 0.90 corresponding to a threshold is displayed thickly, and expresses the resist pattern profile formed. Here, since a resist is a negative mold, it supports the field to which a resist remains [average sensitization agent concentration / 0.90 or less place].
[0065] Drawing 16 (a) is the case where it is resist thickness zd=0.745micrometer whose dimension corresponds by layer structure A and layer structure B. At this time, both patterns formed on layer structure A and layer structure B became the same dimension. On the other hand, drawing 16 (b) is the case where it is resist thickness zd=0.760micrometer from which the difference of the pattern dimension formed on layer structure A and layer structure B serves as the maximum. In this case, the pattern dimension formed on layer structure A became eye small **, and the pattern dimension formed on layer structure B became oversized.
[0066] By the above, resist thickness was able to be set up so that the variation of tolerance by difference of layer structure might be controlled.
[0067] (Example 5) In the example 5, distortion of the image depending on substrate structure is predicted using the simulation approach shown in the example 1, and the amendment approach of the mask pattern configuration for amending this distortion is shown.
[0068] The mask pattern made applicable to count is as being shown in drawing 17 , and is a rectangle pattern whose line breadth the die length of a lengthwise direction is 1.0 micrometers, and is 0.26 micrometers. Here, a white field is an opening mask which penetrates light, and the slash field expresses the chromium film which does not let light pass. The layer structure of the exposed substrate which imprints this mask pattern is two kinds shown in drawing 14 , and as this shows drawing 15 , it is arranged adjacently. Resist thickness could be zd=0.792micrometer. The conditions of other optical intensity-distribution count and average sensitization agent concentration distribution count presupposed that it is the same as that of an example 3.
[0069] Drawing 19 (a) and (in the case of the mask pattern before amendment), the average sensitization agent concentration distribution acquired in simulation is shown. Line breadth is [the direction on layer structure B] small. In this case, what is necessary is just to amend widely the line breadth of the part imprinted on layer structure B, as shown in drawing 18 in order to form a desired pattern. Here, a white field is an opening mask which penetrates light, and the slash field expresses the chromium film which does not let light pass. Thus, drawing 19 (b) and (in the case of the mask pattern after amendment), the average sensitization agent concentration distribution when imprinting the amended pattern is shown. By amending the line breadth of the pattern of the part imprinted on layer structure B, the difference of the pattern dimension by difference of layer structure has been controlled.
[0070]

[Effect of the Invention] The information about the standing wave effectiveness in the resist layer depending on the conditions of the structure of the thickness of a resist and a substrate layer, the antireflection film, etc. is included in sensitization agent concentration distribution in the resist thin film in an exposed substrate. Since the dimension fluctuation which originates in the standing wave effectiveness by averaging this sensitization agent concentration distribution in the depth direction of a resist layer can be predicted, it can predict that a resist pattern dimension and a profile change with conditions of the structure of the thickness of a resist, and a substrate layer, an antireflection film, etc. Using this simulation approach, the layer structure of an exposed substrate can be designed so that a desired pattern can be formed. Moreover, this simulation approach can be used as a tool for the proximity effect correction in consideration of the effect of the layer structure of an exposed substrate.

[Translation done.]